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MEMORANDUM

SUBJECT: Metals in Soils - A Brief Summary

FROM: Field Studies Branch
Exposure Evaluation Division (TS-798)

TO: Jim Everts
Toxic Substances Coordinator

Enclosed for your information is a paper which provides data on average metal levels in soil. This paper was prepared at the request of Enforcement personnel in one region so that they would have average metal levels in soils to compare against the measured levels determined for materials at hazardous waste sites.

The Field Studies Branch, in the Exposure Evaluation Division of the Office of Pesticides and Toxic Substances, conducts several national monitoring networks that determine ambient levels of various pesticide residues and toxic substances, including several heavy metals, in air, surface water, and soil. The staff of this Branch prepared the enclosed paper, entitled "Metals in Soils: A Brief Summary".

If you have any comments or questions about the enclosed paper or wish to receive additional copies of it, please call Ann Carey or Ellen Barrett at FTS/755-8060.

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Metals in Soils: A Brief Summary

Metals are naturally-occurring constituents of soils, and are derived from the rock, or parent materials, from which the soil was formed. Background concentrations of metals in soil, therefore, may vary from region to region. Metal concentrations in the surface layers of soil may also be enriched by several kinds of human activities: burning of fossil fuels, metal-smelting, the application of metal-containing pesticides or fertilizers, as well as waste spillage or dumping.

A brief summary of the levels of seventeen metals in soils follows.

A. Arsenic (As)

The total concentration of arsenic in soils is 6 ppm as reported by Allaway (1) and Lisk. (2). Arsenic levels can reach 121 and 183 ppm in orchards where arsenical pesticides have been used (2).

In Ontario soils sampled to 15 cm (6 inches) arsenic ranged from 1.1-126 ppm (3). In soils where no arsenic compounds were used the range was 1.1-16.7 ppm and the mean was 6.27 ± 2.67 ppm. Apple orchard soils had a mean of 54.2 ± 35.4 ppm. Soils not subjected to arsenic use had the following means:

sandy soils	-	5.84 ± 4.60 ppm	}
clay soils	-	6.43 ± 3.69 ppm	

B. Barium (Ba)

In 863 samples of the top 8 inches of United States soils Shacklette et al. found the geometric mean of barium to be 430 ppm (4).

C. Boron (B)

From a table by Allaway (1) the total concentration in soil is 10 ppm; the range is 2-100 ppm.

In Scotland (5) the mean water extractable B in rural arable land is 0.70 ppm and it is 1.18 ppm in urban gardens.

D. Cadmium

Ryan et al. (6) report that soil cadmium levels range from 0.01-22 ppm while 0.06-0.50 ppm are considered normal.

Baker and Chesnin (7) present a table stating that 0.05 ppm is the average level of cadmium in soils and the usual range is 0.01-0.70 ppm.

Ward et al. state that 0.5 ppm is the background level of cadmium in the surface 5 cm (2 inches) of soil (8).

Chaney (personal communications) says that most of the country has less than 0.2 ppm Cd in soils and that few soils have greater than 1 ppm Cd.

A report of a Michigan study, states that residential areas have an average of 0.41 ppm Cd and agricultural areas have an average of 0.57 ppm. An industrial area had an average of 0.66 ppm Cd (9).

E. Chromium (Cr)

From a table by Allaway (1) the total concentration in soil is 100 ppm and the range is 5-3,000 ppm.

American soils may contain from 1-1,500 ppm based on work by Shacklette et al. (2)

F. Cobalt (Co)

Allaway (1) reports that the cobalt content of soils is 8 ppm.

Another study in Ontario determined that values generally ranged from 1.0 - 65.8 ppm and averaged approximately 4.6 ppm. Fifteen of the 296 samples had greater than 9.0 ppm (3).

G. Copper (Cu)

From a table by Allaway (1) the total concentration in soil is 20 ppm and the range is 2-100 ppm.

A survey of Ontario agricultural soils found (3):

Mean total Cu concentration in soil is 25.4 ± 21.5 ppm

Range: 2.1 - 144 ppm

Mean in organic soils: 65.0 ± 26.9 ppm

Mean in sandy soils: 20.2 ± 27.8 ppm

A Missouri study (10) compared a farm near a smelter to a similar control farm and found the total copper concentration of the control farm soil to be:

fall - 5.71 ppm

winter - 7.58 ppm

spring - 7.82 ppm

summer - 6.50 ppm

H. Fluorine (F)

The mean total amount of fluorine in soils is 200 ppm and ranges from 30-300 ppm (1).

Fleischer* and Robinson (11) report that 285 ppm is an average level for fluorine in soils.

Total soil fluorine varies widely with each type of soil. Fluorine is relatively immobile and non-soluble. Total fluorine ranges from 136-990 ppm and averages about 377 ppm (12).

I. Lead (Pb)

A table by Allaway (1) gives the mean total concentration in soil to be 10 ppm with a range of 2-200 ppm.

Lisk (2) reports the range in arable soils is 0.8-500 ppm. Lead concentrates in the surface of soils (8,13).

Lead occurs in all soils with a mean total concentration 15 ppm and a range of 1-200 ppm (14).

In uncontaminated agricultural soils the mean total concentration is 50 ppm mean and the range is 2-200 ppm (15).

In Ontario, a survey showed soil Pb levels to be 14.1 ± 9.5 ppm in the top 15 cm (6 inches). Values ranged from 1.5-23.6 for these uncontaminated soils (2).

Farmlands in British Columbia, other parts of Canada, New Zealand, and the U.S. have a mean of 10.6 ppm Pb, and values range from 0.6 - 180.4 ppm Pb in the plow layer (16).

John et al. report that the total level of Pb in the surface mineral horizon of Canadian soils range from 12.0 to 999.4 ppm. The median he found was 33.6 ppm. (17).

The total lead content of soils in this country average 16 ppm and range from 10-700 ppm (2).

Near old homes painted with lead-based paints soils may have elevated lead levels. They have been reported as high as 450 ppm and 360 ppm (18, 19).

Near highways lead increases in the top 5 cm to 522 ppm in Beltsville, Maryland, 232 ppm in Platte City, Missouri, and 150 ppm in Cincinnati, Ohio (11).

J. Manganese (Mn)

Allaway (1) reported that the total concentration of manganese in soils is 850 ppm with a range of 100-4,000 ppm.

Well-drained Alberta agricultural soils, representing natural levels of manganese, have approximately 250 ppm manganese in the plow layer (top 8 inches). Poorly drained soils generally have higher concentrations of manganese. An earlier report showed the range to be 80-550 ppm in Alberta (21).

K. Mercury (Hg)

Lisk (2) reported that soils generally have 0.3 ppm mercury.

Hugunin et al. reported that the natural concentration of mercury is approximately 0.10 ppm (22).

Vinogradov reported the worldwide average for mercury in soils is 0.010 ppm and Hawkes and Well reported soils range from 0.03-0.30 ppm mercury (23).

Shacklette's survey of U.S. soils showed that eastern U.S. soils generally range from 0.01 - 3.40 ppm and that western soils range from 0.01 - 4.60 ppm mercury (2).

Another study (22) found the following:

Western U.S. soils	-	geometric mean	-	0.055 ppm
		arithmetic mean	-	0.112 ppm
Eastern U.S. soils	-	geometric mean	-	0.096 ppm
		arithmetic mean	-	0.147 ppm

While most California soils have 0.02 - 0.04 ppm mercury, those in the Franciscan Formation have 0.10 - 0.20 ppm Hg (24).

Two studies were done in Canada. They report that in Ontario the natural background level is 0.08 ppm soils in mineral soils and 0.11 ppm in organic soils (3). Alberta plow layer soils range from 0.02 to 0.04 ppm Hg. However, poorly drained soils tend to have higher mercury concentrations (21).

L. Nickel (Ni)

Lisk (2) and Allaway (1) report that the average level of nickel in soils is 40 ppm.

A study in Ontario found that agricultural soils ranged from 1.3 - 6,560 ppm. However, several sites were contaminated by a nearby smelter. The uncontaminated soils averaged 15.9 ± 16 ppm nickel (3).

With an HCl extraction, Dudas and Rawluk (21) found the average level of nickel varied with the soil classifications but were generally around 7.0 ppm.

M. Selenium (Se)

The total amount of selenium in soils are reported to be 0.5 ppm by Allaway (1) and 0.2 ppm by Lisk (2).

N. Silver (Ag).

In a table by Lindsay (25) the average silver content of soils is reported to be 0.05 ppm and commonly range from 0.01-5 ppm. Lisk's table (2) provides 0.1 ppm as the average level of silver in soil.

O. Strontium (Sr)

Allaway's table (1) reports that soils have approximately 300 ppm strontium and range from 50 - 1,000 ppm. The value reported by Lisk is also 300 ppm (2).

Dudas and Pawluk (21) found that agricultural soils in Alberta had 10 - 99 ppm strontium. Some poorly drained soils had significantly more strontium than comparable well-drained soils.

P. Thallium (Tl).

The level Lisk (2) reports for thallium in soil is 5 ppm.

Q. Zinc (Zn)

Allaway (1) reports that the average level of zinc in soils is 50 ppm.

In Canada soils range from 22.4 - 346.9 ppm and the median value is 68.9 ppm Zn (2).

Soils in Missouri have been reported to contain about 22 ppm Zn (10). Close to major highways, levels of Zn may reach 172 ppm and drop to 54 ppm at 32 meters from the highway (16).

Urban gardens have been found to have higher levels than rural arable soils (5).

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